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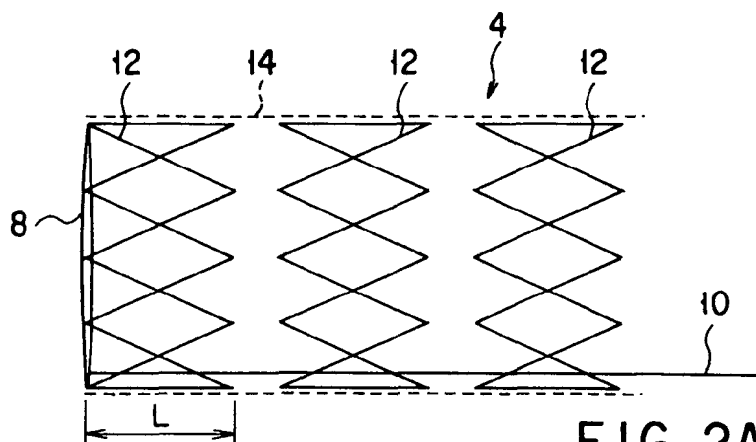
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(54) **Stent**

(57) A stent (2) for dilating an internal lumen includes tubular segments (12) that are arranged side by side in its axial direction. Each segment expands and

contracts in the diametrical direction of the stent, and its axial length (L) is shorter than its expanded-state radius (R).



**FIG. 2A**

## Description

[0001] The present invention relates to a stent for dilating an internal lumen.

[0002] Methods for recovering an indwelling stent are described in Jpn. Pat. Appln. KOKAI Publication No. 10-192411 and U.S. Pat. No. 5,474,563, for example. In these methods, the opposite ends of the stent are axially pulled in opposite directions to contract the stent diametrically inward as the stent is separated from an internal lumen and recovered. Described in European Patent Application Publication No. 423,916 is a method in which a stent is drawn out and recovered with its proximal end side contracted diametrically inward.

[0003] In many cases, tumors cause constriction of lumens, especially the lumen of a pancreatic or biliary duct system. If a stent is indwelled in one such lumen for a long period of time, the mucous membrane of the lumen may possibly grow into the stent through its stitches or adhere to the mucous membrane.

[0004] In recovering the indwelling stent, therefore, it must be separated from the mucous membrane. In the case where the indwelling stent is of a self-expansion type, it is pressed against the mucous membrane in the lumen, making it difficult to be drawn out for recovery.

[0005] The present invention is to provide a stent capable of being easily recovered from a lumen.

[0006] According to an aspect of the invention, a stent for dilating an internal lumen according to an aspect of the invention comprises tubular segments capable of expanding and contracting in the axial direction thereof and having an axial length shorter than the expanded-state radius thereof, the segments being arranged side by side from the distal side to the proximal side in the axial direction.

[0007] This summary of the invention does not necessarily describe all necessary features so that the invention may also be a sub-combination of these described features.

[0008] The invention can be more fully understood from the following detailed description when taken in conjunction with the accompanying drawings, in which:

FIG. 1A is a schematic perspective view showing a stent according to a first embodiment of the invention indwelled in a lumen;

FIG. 1B is a schematic perspective view showing a process for turning the stent of FIG. 1A inside out by means of a holding forceps;

FIG. 1C is a schematic perspective view showing a process in which the stent of FIG. 1B is further turned back;

FIG. 2A is a schematic front view of a tubular member showing the stent according to the first embodiment indwelled in the lumen;

FIG. 2B is a side view of the stent shown in FIG. 2A; FIG. 2C is a schematic front view of the tubular member showing a process for turning the stent of

FIGS. 2A and 2B inside out;

FIG. 2D is a side view of the stent shown in FIG. 2C; FIG. 2E is a schematic front view of the tubular member showing a process in which the stent of FIGS. 2C and 2D is further turned back;

FIG. 2F is a side view of the stent shown in FIG. 2E; FIG. 2G is a schematic front view of the tubular member showing a process in which the stent of FIGS. 2E and 2F is turned back;

FIG. 2H is a side view of the stent shown in FIG. 2G; FIG. 3A is a schematic view showing a stent delivery system;

FIG. 3B is a schematic view showing the way the stent of FIG. 1A is orally guided to a duodenal papilla by means of an endoscope;

FIG. 4A is a schematic front view taken from the outside, showing a wire of a stent having a plain-stitch structure according to a second embodiment; FIG. 4B is a side view corresponding to FIG. 4A;

FIG. 4C is an axial sectional view corresponding to FIG. 4A;

FIG. 5 is a schematic view showing the way loops shown FIGS. 4A to 4C are formed and the respective names of the loops in this state;

FIG. 6A is a schematic view showing reverse-side loops of the plain-stitched wire of the stent according to the second embodiment;

FIG. 6B is an axial sectional view of the wire of FIG. 6A bent in the lumen;

FIG. 7A is a schematic view showing face-side loops of a plain-stitched wire of a prior art stent;

FIG. 7B is an axial sectional view of the wire of FIG. 7A bent in the lumen;

FIG. 8A is a schematic perspective view showing a holding forceps for stent recovery according to the second embodiment;

FIG. 8B is a schematic perspective view showing the way the holding forceps of FIG. 8A is inserted into the stent indwelled in the lumen;

FIG. 8C is a schematic perspective view showing the way a forceps portion of the holding forceps are spread and passed through the stent of FIG. 8B from inside to outside;

FIG. 8D is a schematic perspective view showing the way the holding forceps of FIG. 8C is closed so that return portions are hooked on stitches of the stent;

FIG. 8E is a schematic perspective view showing the way the distal end of the stent is diametrically contracted as it is returned to the proximal end side; FIG. 9A is a schematic view showing a wire according to a third embodiment used in the stent according to the second embodiment;

FIG. 9B is a schematic view showing another wire according to the third embodiment used in the stent according to the second embodiment;

FIG. 9C is an enlarged view of a portion 9C shown in FIG. 9B;

FIG. 10A is a front view showing a stent according to a fourth embodiment in a state such that segments formed of wires waved in the form of a tube are each arranged side by side and covered with a filmy member;

FIG. 10B is a side view of the stent shown in FIG. 10A;

FIG. 11A is an axial sectional view showing a plain-stitched wire according to a fifth embodiment designed so that face-side loops appear on its outer peripheral surface with the other portion than an end portion reversed; and

FIG. 11B is an axial sectional view showing a state in which the other portion than the end portion shown in FIG. 11A is restored to its original state such that reverse-side loops appear on the outer peripheral surface.

**[0009]** Preferred embodiments of the present invention will now be described with reference to the accompanying drawings.

**[0010]** A first embodiment will first be described with reference to FIGS. 1A to 3B. As shown in FIG. 1A, a stent 2 according to this embodiment includes a tubular member 4, preferably in the form of a hollow cylinder, a looped member 8 twined in a distal end 6 of the tubular member 4, and a pull thread 10 connected to the looped member 8. The looped member 8 can be expanded or contracted in its diametrical direction. The pull thread 10 further extends to the distal side through the bore of the tubular member 4.

**[0011]** In the tubular member 4, as shown in FIG. 2A, tubular segments 12 that are each formed of a wire are arranged side by side in the axial direction. A tubular filmy member 14 that is expansible in its diametrical direction is fixed on the segment assembly 12. Each segment 12 has a force to expand outward in the diametrical direction, and can contract inward in the diametrical direction. Thus, the filmy member 14 is expanded and contracted in the diametrical direction as the segment assembly 12 expand and contract. Preferably, each segment 12 is formed by zigzagging a wire of a metallic material, elastic resin material, or organic material. The axial length of each segment assembly 12 is L, which is shorter than a radius R (see FIG. 2B) of the segment assembly 12 in a diametrically expanded state. The length L and the radius R change as the segment assembly 12 expands and contracts. As shown in FIG. 2A, the looped member 8 is twined in the distal end 6 of the segment 12 on the extreme distal side, and is connected to the leading end (distal end) 6 of the filmy member 14 by adhesive bonding, for example.

**[0012]** The stent 2 can be indwelled in a narrow segment 22 in an internal lumen in the following manner by using a stent delivery system 20, for example. As shown in FIG. 3A, the stent delivery system 20 is composed of an inner catheter 17 having a hemispherical protuberance 17a and an outer sheath 21 that covers the periph-

ery of the catheter 17. The outside diameter of the protuberance 17a is substantially equal to that of the outer sheath 21. The protuberance 17a has a through hole 17b that opens into the bore of the inner catheter 17. Preferably, a guide wire (not shown) or the like should be able to be passed forward through the hole 17b. The outer sheath 21 can move relatively to the inner catheter 17 in the axial direction of the catheter 17.

**[0013]** The stent 2 is reduced in diameter and held between the outer periphery of the inner catheter 17 and the inner periphery of the outer sheath 21. As the tubular member 4 is then pressed diametrically inward, the segment assembly 12, along with the filmy member 14, is contracted diametrically inward. The hand-side portion of the pull thread 10 is located on the proximal end side of the stent delivery system 20. If the outer sheath 21 is pulled relatively to the inner catheter 17 to the hand side with the distal end of the stent 2 thus situated near the protuberance 17a, the stent 2 is rendered gradually self-expanded from its leading end toward its trailing end by means of the diametrically outward expanding force of the segment assembly 12, as shown in FIGS. 3A and 3B.

**[0014]** As shown in FIG. 3B, the stent delivery system 20 thus fitted with the stent 2 is caused orally to reach a duodenal papilla 18 through a channel of a lateral-view endoscope 16, for example. The protuberance 17a of the stent delivery system 20 is further introduced into the inner part of the narrow segment 22 so that the system 20 is brought to a position just ahead of the narrow segment 22 in the lumen.

**[0015]** If the outer sheath 21 of the stent delivery system 20 is pulled relatively to the inner catheter 17 to the hand side in this state, the stent 2 is rendered self-expanded outward from its leading end in the diametrical direction of the lumen, whereby the narrow segment 22 is expanded gradually. The outer sheath 21 is further pulled to expand the stent 2 to its proximal end, thereby expanding the narrow segment 22 to form a wide passage in the lumen. Thereafter, the inner catheter 17 is pulled and taken out to the hand side through the bore of the stent 2 (segment assembly 12). If the stent 2 is released from the stent delivery system 20, therefore, it is rendered self-expanded outward from its leading end in the diametrical direction of the lumen, and indwelled in the narrow segment 22 in a dilated state. Thus, the stent 2 presses the inner wall (mucous membrane) in the lumen, thereby dilating the lumen diametrically outward.

**[0016]** The following is a description of processes for recovering the stent 2 expanded in this manner. The pull thread 10 of the stent 2 indwelled in the state shown in FIG. 1A is held by means of a forceps portion 26 of a holding forceps 24, for example, and pulled to the hand side, as shown in FIG. 1B. The looped member 8 is gradually contracted inward in the diametrical direction of the stent 2, as shown in FIGS. 1B and 2C. If the pull thread 10 is further pulled, the looped member 8 and the distal

end 6, which are contracted diametrically inward, are drawn into the stent 2, as shown in FIG. 1C. Finally, the stent 2 is turned inside out as it is separated diametrically inward from the lumen (narrow segment 22) and recovered.

[0017] The movement of the segment 12 on the side of the distal end 6 in this state, in particular, will be described with reference to FIGS. 2A to 2H.

[0018] FIG. 2A, like FIG. 1A, shows the stent 2 indwelled in the lumen. If the pull thread 10 is pulled to the hand side, the looped member 8 starts to diminish diametrically inward, and the segment 12 on the distal side starts to contract diametrically inward, as shown in FIGS. 2C and 2D, as in FIG. 1B. If the pull thread 10 is pulled further, the looped member 8 is further contracted diametrically inward, and the segment 12 on the distal side is folded in, as shown in FIGS. 2E and 2F. If the pull thread 10 is pulled further, the looped member 8 and the extreme distal-side segment 12, contracted diametrically inward, are gradually turned inside out as they are drawn into the adjacent segments 12 on the proximal side. As this is done, the axial length L of each segment 12 is shorter than the radius R of each expanded segment 12, and the adjacent zigzag segments 12 cannot easily interfere with one another as they are turned inside out in the state shown in FIGS. 2E and 2G.

[0019] If the pull thread 10 is further pulled, the segment 12 next to the extreme-end segment 12 is turned inside out in the same manner as the end segment 12 as it is drawn into the adjacent segments 12 on the proximal side. The segments 12 arranged on the distal side are successively drawn into the adjacent segments 12 on the proximal side in this manner. Then, the whole stent 2 is turned inside out as it is separated diametrically inward from the inner wall (mucous membrane) in the lumen, and is taken out and recovered from the narrow segment 22.

[0020] In recovering the stent 2 of FIGS. 1A and 2A that is indwelled in the narrow segment 22 in the lumen, therefore, the stent 2 is gradually separated inward in the diametrical direction or in the direction perpendicular to the mucous membrane from the side of the distal end 6. Thus, the possibility of the stent 2 rubbing against the mucous membrane in the lumen can be lowered even in an initial stage of turning the stent 2 inside out, so that a burden on the lumen can be lightened. As the separation from the mucous membrane advances, the area of contact between the stent 2 and the mucous membrane decreases. Even in case the stent 2 heavily adheres to the mucous membrane, therefore, it can be separated and recovered relatively easily.

[0021] In the stent 2 according to this embodiment, the pull thread 10 may be located in the duodenal papilla 18 or extend to the duodenum so that it can be recognized through the endoscope 16. Further, a ball (not shown) or the like may be attached to the proximal side of the pull thread 10 so that a satisfactory drawing force can be applied to the holding forceps that holds the

thread.

[0022] The pull thread 10 should preferably be formed of a high-resistance material that stands the drawing force, such as a metallic wire, polyamide-based plastic fiber thread (string), or silk thread. The filmy member 14 should preferably be formed of a thin, tear-resistant material, e.g., an elastic resin or organic material, such as a fluoroplastic, silicone, or urethane resin. The filmy member 14 may be made of bio-absorbable and biodegradable material, such as polymers of polylactic acid or polyglycolic acid.

[0023] A second embodiment will now be described with reference to FIGS. 4A to 8E. As shown in FIGS. 4A to 4C, a tubular member of a stent 27 according to this embodiment is formed of a wire that has a plain-stitch structure. Each tier of stitches corresponds to one segment 28. The segments 28 are tied to form a tube type segment assembly. As shown in FIG. 5, a loop is formed of a needle loop and a sinker loop. The needle loop is a loop that is formed in the wire by means of a needle (not shown). The sinker loop is a loop that is formed as the needle loop is formed. As shown in FIG. 4A, the axial length of each segment 28 is represented by L. The length L is shorter than the radius R of each segment 28 that is expanded in the axial direction (see FIGS. 4A and 4B).

[0024] Preferably, the plain-stitched segment assembly 28 is covered by a filmy member (not shown). The filmy member can freely expand and contract in its diametrical direction. Preferably, this wire is formed of a superelastic alloy or shape-memory alloy, and can freely expand and contract in its diametrical direction.

[0025] As shown in FIGS. 6A and 6B, the plain-stitched segments 28 are arranged so that the reverse-side loop of each plain stitch faces outward. In this stitch structure, as shown in FIG. 6A, the needle loops of a segment 28a in a certain tier are hooked on the outside of the needle loops of a segment 28b in the next tier ahead. Further, the sinker loops of the segment 28a are hooked on the outside of the sinker loops of a segment 28c in the next tier behind. The sinker loops of the segment 28a are arranged so that they are led from inside to outside through the sinker loops of the segment 28b in the next tier ahead to be hooked on the outside of the needle loops. Thus, a needle loop in a certain position never fails to be hooked on the outside of a needle loop in the next tier ahead, while a sinker loop never fails to be hooked on a sinker loop in the next tier behind from outside.

[0026] As shown in FIG. 6B, therefore, engaging portions 30 between the segment 28a in each certain tier of the stitch structure shown in FIG. 6A and the segments 28b and 28c in the next tiers ahead and behind are arranged facing outward, as shown in FIG. 6B.

[0027] As shown in FIG. 7A, moreover, the prior art plain-stitched wire has a structure such that the face-side loop of each plain stitch faces outward. In this stitch structure, as shown in FIG. 7A, the needle loops of a

segment 28d in a certain tier are hooked on the inside of the needle loops of a segment 28e in the next tier ahead. Further, the sinker loops of the segment 28d are hooked on the inside of the sinker loops of a segment 28f in the next tier behind. The sinker loops of the segment 28d are arranged so that they are led from outside to inside through the outside of the sinker loops of the segment 28e in the next tier ahead to be hooked on the inside of the needle loops. Thus, a needle loop in a certain position never fails to be hooked on the inside of a needle loop in the next tier ahead, while a sinker loop never fails to be hooked on a sinker loop in the next tier behind from inside.

**[0028]** As shown in FIG. 7B, therefore, engaging portions 30 between the segment 28d in each certain tier of the stitch structure shown in FIG. 7A and the segments 28e and 28f in the next tiers ahead and behind are arranged facing inward, as shown in FIG. 7B. If the stent formed of segment assembly 28 is bent, its bore is collapsed so that its inside diameter inevitably becomes smaller than when in the expanded state.

**[0029]** In the stent 27 according to this embodiment shown in FIG. 6B, on the other hand, the engaging portions 30 face outward. If the stent 27 is bent, therefore, its inside diameter can be kept at its normal-state value or made greater. If the reverse-side loop structure is made to face outward, as shown in FIG. 6B, therefore, the stent 27 cannot be easily changed in diameter when it is bent. Thus, a constant diameter can be maintained in the lumen.

**[0030]** The stent 27, like the stent 2 according to the embodiment, can be indwelled in the lumen. The inner catheter 17 of the stent delivery system 20 shown in FIG. 3A is inserted into the stent 27. In the case where the stent 27 is fitted in the outer sheath 21, the plain-stitched segments 28, along with the filmy member, are pressed and contracted diametrically inward. If the stent 27 is released from the stent delivery system 20, as shown in FIG. 3A, it is rendered self-expanded outward in the diametrical direction of the lumen and indwelled in the narrow segment 22 in a dilated state, as shown in FIG. 3B. Thus, the stent 27 presses the inner wall (mucous membrane) in the lumen, thereby dilating the lumen diametrically outward.

**[0031]** The following is a description of processes for recovering the stent 27 expanded in this manner. In this case, a holding forceps 40 for stent recovery is used, as shown in FIG. 8A. The holding forceps 40 is composed of a sheath 42 and holding portions 44 that project from the distal end of the sheath 42 and are spreadable in the diametrical direction and retractable in the axial direction. The distal end of each holding portion 44 is provided with a return portion 46 that can be hooked on the segments 28 of the stent 27 that has the stitch structure inside. The return portions 46 have a moderate curvature to avoid damage to the mucous membrane. The stent 27 is indwelled in the same manner as the stent 2 according to the first embodiment.

**[0032]** First, the holding forceps 40 is inserted axially into the stent 27, as shown in FIG. 8B. Then, the holding portions 44 of the holding forceps 40 are stretched forward and spread, passed outward through the stitches of the segment 28 on the inner wall on the distal end side of the stent 27 from the inside, and brought to the outside of the filmy member, as shown in FIG. 8C.

**[0033]** Then, the holding portions 44 are fully spread so that the return portions 46 are located entirely outside the filmy member. Thereafter, the holding forceps 40 is pulled backward to close the holding portions 44, whereupon the return portions 46 are hooked on the distal-side segment 28, as shown in FIG. 8D. After it is confirmed that the return portions 46 are hooked on the distal end side of the stent 27, the holding portions 44 are further closed. As shown in FIG. 8E, the distal side of the stent 27 is contracted diametrically inward as it is pulled back to the proximal side, whereupon the distal side of the stent 27 is drawn into the stent 27. The stent 27 is further drawn into itself, and the whole stent 27 is turned inside out as it is separated diametrically inward from the inner wall (mucous membrane) in the lumen (narrow segment 22). Thus, the stent 27 can be recovered.

**[0034]** In recovering the stent 27 of FIGS. 4A to 8E that is indwelled in the lumen, therefore, the stent 27 is gradually separated inward in the direction perpendicular to the mucous membrane from the distal side. Thus, the possibility of the stent 27 rubbing against the mucous membrane in the lumen can be lowered in an initial stage of turning the stent 27 inside out, so that the burden on the lumen can be lightened. As the separation from the mucous membrane advances, the area of contact between the stent 27 and the mucous membrane decreases. Even if the stent 27 heavily adheres to the mucous membrane, therefore, it can be separated and recovered relatively easily.

**[0035]** The holding forceps 40 for stent recovery may be a four-prong holding forceps, as shown in FIG. 8A. Alternatively, however, it may be a three- or five-prong holding forceps, for example. The return portions 46 are larger than the stitches of the segments 28 of the stent 27. If the return portions 46 are pulled back after they are once passed through the stitches, therefore, it is hard for them to pass through the same stitches and be disengaged. Thus, the holding forceps 40 can satisfactorily hold the stent 27 and recover it with ease. Preferably, the filmy member should be removably attached to the plain-stitched segments 28 so as to cover them. However, it is not essential.

**[0036]** A third embodiment will now be described with reference to FIGS. 9A to 9C. This embodiment is a modification of the first and second embodiments. As shown in FIG. 9A, a tubular member of a stent 32 according to this embodiment comprises tubular segments 34 that are each formed of a zigzagged wire and are arranged side by side in the axial direction. The adjacent segments 34 are connected to one another by means of

string or rubber band connecting members 35. The segment assembly 34 can freely expand and contract in diametrical and axial directions. The axial length L of each segment 34 is shorter than its diametrically-expanded-state radius R.

**[0037]** The stent 32, like the stents 2 and 27 according to the first and second embodiments, can be indwelled in the lumen. The inner catheter 17 of the stent delivery system 20 shown in FIG. 3A is inserted into the stent 32. If the stent 32 is fitted in the outer sheath 21, the segments 34 are pressed and contracted diametrically inward. If the stent 32 is released from the stent delivery system 20, as shown in FIG. 3A, it is rendered self-expanded outward in the diametrical direction of the lumen and indwelled in the narrow segment 22 in a dilated state, as shown in FIG. 3B. Thus, the stent 32 presses the inner wall (mucous membrane) in the lumen, thereby dilating the lumen diametrically outward.

**[0038]** Since the stent 32 can be recovered in the same manner as the stent 27 according to the second embodiment, a description of its recovery is omitted.

**[0039]** In recovering the stent 32 of this embodiment shown in FIG. 9A that is indwelled in the lumen, as in the case of the second embodiment, therefore, the stent 32 is gradually separated in the direction perpendicular to the mucous membrane from the distal end side. Thus, the possibility of the stent 32 rubbing against the mucous membrane in the lumen can be lowered in an initial stage of turning the stent 32 inside out, so that the burden on the lumen can be lightened. As the separation from the mucous membrane advances, the area of contact between the stent 32 and the mucous membrane decreases. Even if the stent 32 strongly adheres to the mucous membrane, therefore, it can be separated and recovered relatively easily.

**[0040]** According to this embodiment, the string or rubber band connecting members 35 are used to connect the segments 34 to one another. Alternatively, however, a stent 38 may be formed in a manner such that each wire that constitutes a segment is connected to and across wires that constitute its adjacent segments 36, as shown in FIG. 9B and in the enlarged view of FIG. 9C that illustrates the portion 9C in FIG. 9B.

**[0041]** A fourth embodiment will now be described with reference to FIGS. 10A and 10B. This embodiment is a modification of the second embodiment. As shown in FIG. 10A, a tubular member 49 of a stent 48 according to this embodiment is composed of segment assembly 50, each of segments 50 composed of a tube of a wavy wire, and a filmy member 51 that can freely expand and contract in the diametrical direction and covering the segment assembly 50, each of segments 50 arranged side by side. The segment assembly 50 can freely contract and expand in the diametrical direction. As shown in FIGS. 10A and 10B, the axial length L of each of segments 50 is shorter than its diametrically-expanded-state radius R.

**[0042]** The stent 48, like the stent 27 according to the

second embodiment, can be indwelled in the lumen. The inner catheter 17 of the stent delivery system 20 shown in FIG. 3A is inserted into the stent 48. In the case where the stent 48 is fitted in the outer sheath 21, the tubular member 49 is pressed and contracted diametrically inward. If the stent 48 is released from the stent delivery system 20, as shown in FIG. 3A, it is rendered self-expanded outward in the diametrical direction of the lumen and indwelled in the narrow segment 22 in a dilated state, as shown in FIG. 3B. Thus, the stent 48 presses the inner wall (mucous membrane) in the lumen, thereby dilating the lumen diametrically outward.

**[0043]** Since the stent 48 can be recovered in the same manner as the stent 27 according to the second embodiment, a description of its recovery is omitted.

**[0044]** In recovering the stent 48 of this embodiment shown in FIG. 10A that is indwelled in the lumen, as in the case of the second embodiment, therefore, the stent 48 is gradually separated in the direction perpendicular to the mucous membrane from the distal end side. Thus, the possibility of the stent 48 rubbing against the mucous membrane in the lumen can be lowered in an initial stage of turning the stent 48 inside out, so that the burden on the lumen can be lightened. As the separation from the mucous membrane advances, the area of contact between the stent 48 and the mucous membrane decreases. Even if the stent 48 strongly adheres to the mucous membrane, therefore, it can be separated and recovered relatively easily. Since its distal end portion 52 is not pointed, moreover, the stent 48 can be readily recovered without easily catching and damaging the mucous membrane in the lumen.

**[0045]** A fifth embodiment will now be described with reference to FIGS. 11A and 11B. This embodiment is a modification of the second embodiment. Usually, a wire having a plain-stitch structure is formed so that face-side loops appear on its outer peripheral surface, as shown in FIG. 7B. After this wire is turned inside out so that the reverse-side loops shown in FIG. 6B appear on its outer peripheral surface, the filmy member is provided on the outer peripheral surface of the wire to realize the second embodiment. In this case, a stent 54 is urged to return to a state such that face-side loops 60 such as the ones shown in FIG. 7B appear on its outer peripheral surface. Accordingly, there is the possibility of the stent 54 being gradually outwardly turned inside out from its end portion and then turned entire only when it is subjected to a small shock or the like in a non-loaded state. Thus, there is the possibility of the stent 54 being turned from a state such that reverse-side loops 62 face outward, as shown in FIG. 11B, to a state such that the face-side loops 60 face outward, as shown in FIG. 11A.

**[0046]** According to this embodiment, therefore, an end portion 56 of the stent 54 is previously subjected to shape-memory processing such the reverse-side loops 62 are obverse with the face-side loops 60 on the outer peripheral surface, as shown in FIG. 11A. In the stent 54 having the reverse-side loops 62 facing outward in

the lumen, as shown in FIG. 11B, the end portion 56 subjected to shape-memory processing is made reluctant to be turned inside out with a small shock. Thus, the stent 54 can be prevented from being unexpectedly turned inside out as it is indwelled in the internal lumen.

[0047] Steps for manufacturing the stent 54 according to this embodiment will now be described with reference to FIGS. 11A and 11B.

[0048] The end portion 56 of the stent 54 that is knitted with the face-side loops 60 on the outside, as shown in FIGS. 7A and 7B, is turned inside out, and is subjected to shape-memory processing with the reverse-side loops 62 in its position facing outward, as shown in FIG. 11A. Thereafter, a portion 58 with the face-side loops 60 on the outside is turned inside out through the inside of the stent 54, as indicated by the arrows in FIG. 11A, so that the reverse-side loops 62 face outward throughout the length of the stent 54. The reverse-side loops 62 are covered entire with a filmy member (not shown) that can expand and contract in the diametrical direction and has a longitudinal length substantially equal to the length of the wire that has the reverse-side loops 62 facing outward. This filmy member is removable from the wire.

[0049] Although only the one end portion 56 is subjected to shape-memory processing for prevention of reversal, both end portions may alternatively be subjected to the same shape-memory processing.

[0050] When the stent 54 of this embodiment manufactured in this manner is indwelled in the lumen, it is designed to resist being turned inside out, as mentioned before. On the other hand, the end portion 56 is reversed inward as it is drawn into the stent 54 by means of the holding forceps 40 shown in FIG. 8A, for example. Thus, the stent 54 can be easily turned inside out when being recovered.

[0051] The stent 54, like the stents 2 and 27 according to the first and second embodiments, can be indwelled in the lumen. The inner catheter 17 of the stent delivery system 20 shown in FIG. 3A is inserted into the stent 54. If the stent 54 is fitted in the outer sheath 21, the plain-stitched wire, along with the filmy member, is pressed and contracted diametrically inward. If the stent 54 is released from the stent delivery system 20, as shown in FIG. 3A, it is rendered self-expanded outward in the diametrical direction of the lumen and indwelled in the narrow segment 22 in a dilated state, as shown in FIG. 3B. Thus, the stent 54 presses the inner wall (mucous membrane) in the lumen, thereby dilating the lumen diametrically outward.

[0052] The following is a description of processes for recovering the stent 54 expanded in this manner. Since the end portion 56 of the stent 54 is shaped, as mentioned before, the whole stent 54 cannot be unexpectedly turned inside out with ease. If the end portion 56 is reversed toward the inside of the stent 54 by means of the holding forceps 40 shown in FIG. 8A, for example, as it is recovered, as described in detail in connection with the second embodiment, the portions 58 other than

the end portion 56 can be relatively easily turned inside out to allow the stent 54 to be recovered as the end portion 56 is drawn into the stent 54.

[0053] In recovering the stent 54 of this embodiment shown in FIG. 11B that is indwelled in the lumen, as in the case of the second embodiment, therefore, the stent 54 is gradually separated in the direction perpendicular to the mucous membrane from the side of the end portion (distal end) 56. Thus, the possibility of the stent 54 rubbing against the mucous membrane in the lumen can be lowered in an initial stage of turning the stent 54 inside out, so that the burden on the lumen can be lightened. As the separation from the mucous membrane advances, the area of contact between the stent 54 and the mucous membrane decreases. Even if the stent 54 heavily adheres to the mucous membrane, therefore, it can be separated and recovered relatively easily.

[0054] Although the processes for recovering the stent from the lumen have been described in connection with the first to fifth embodiments, the stent according to the present invention need not always be a stent to which the aforesaid processes of recovery is applicable, and the invention may be applied to any stent that can be recovered by being turned inside out.

[0055] According to the first to fifth embodiments, as described above, the distal side of the stent is drawn into the stent itself to be turned inside out when being recovered. As the stent is turned inside out, therefore, the area of contact between the stent and the mucous membrane decreases, and the stent is separated diametrically inward (or vertically) from the mucous membrane.

[0056] Since the stent can be easily separated from the mucous membrane, therefore, it can be also recovered with ease. Since there is little possibility of the stent rubbing against the mucous membrane when being recovered, moreover, the burden on the lumen can be minimized. Thus, the stent according to each of the embodiments described herein is particularly effective if it needs to be indwelled in the lumen for a long period of time.

## Claims

1. A stent (2, 27, 32, 38, 48, 54) for dilating an internal lumen, comprising tubular segments (12, 28, 34, 36, 50, 60, 62) capable of expanding and contracting in the radial direction thereof and having an axial length (L) shorter than the expanded-state radius (R) thereof, the segments being arranged side by side from a distal side to a proximal side in the axial direction of the stent.
2. A stent (2, 27, 32, 38, 48, 54) according to claim 1, characterized by further comprises a tubular filmy member (14, 51) located around the segments (12, 28, 34, 36, 50) and urged to expand diametrically

outward by the segments.

segments so that the distal-side segment can be turned back into the proximal-side segment.

3. A stent (2, 27, 32, 38, 48, 54) for dilating an internal lumen, **characterized by** comprising:

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tubular segments (12, 28, 34, 36, 50, 60, 62) having an expanding force in the diametrical direction of the stent and having an axial length (L) shorter than the diametrically-expanded-state radius (R) thereof, the segments being arranged side by side in the axial direction; and a tubular filmy member (14, 51) capable of expanding in the axial direction thereof, the filmy member being attached to the segments so as to cover the same.

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4. A stent (2, 27, 32, 38, 48, 54) according to any one of claims 1 to 3, **characterized in that** the filmy member (14, 51) is made from bio-absorbable material.

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5. A stent (27, 54) according to any one of claims 1 to 4, **characterized in that** each of segments (28, 60, 62) is formed of a wire having a plain-stitch structure with reverse-side loops facing outward.

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6. A stent (48) according to any one of claims 1 to 4, **characterized in that** each of segments (50) is formed of a wavy wire.

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7. A stent (2, 32, 38) according to any one of claims 1 to 4, **characterized in that** each of segments (12, 34, 36) is formed of a zigzagged wire.

8. A stent (54) according to any one of claims 5 to 7, **characterized in that** at least one of the segments (60, 62) located individually on the extreme distal and proximal sides is subjected to shape-memory processing such that face-side loops face outward.

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9. A stent (2) according to any one of claims 5 to 7, **characterized in that** one of the segments (12) located on the extreme distal side is connected with a pulling element (10) extending on the proximal side of the segment on the extreme proximal side, the pulling element being passed through the interior of the segments.

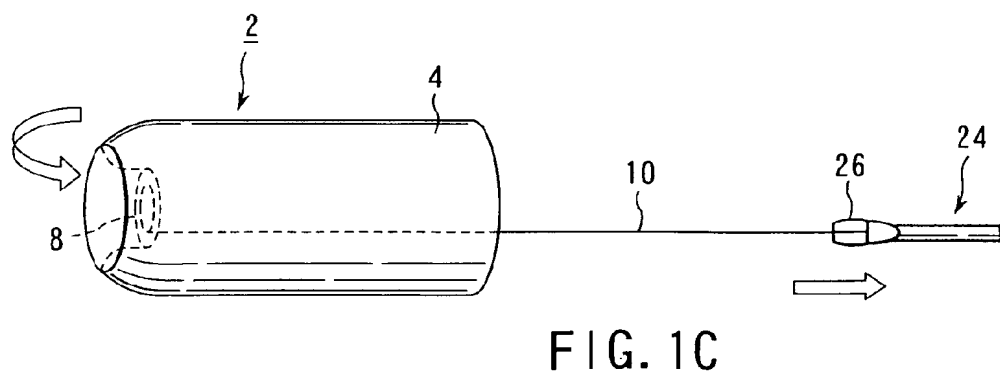
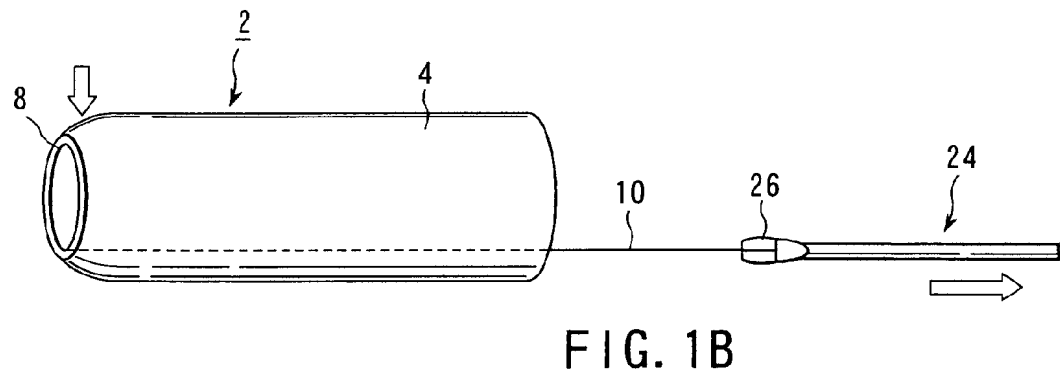
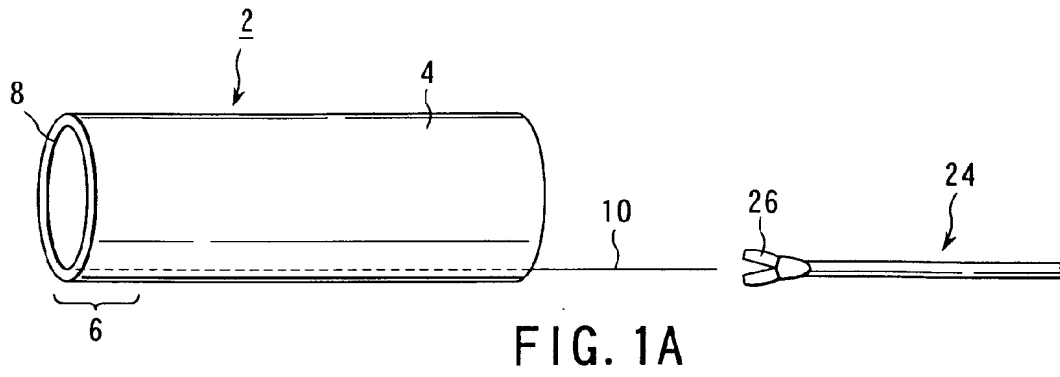
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10. A stent (2) according to claim 9, **characterized in that** one of the segments (12) located on the extreme distal side is provided with a looped member (8) connected with the pulling portion (10).

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11. A stent (32, 38) according to any one of claims 1 to 10, **characterized by** further comprises a connecting portion (35, 9C) capable of connecting each segment (34, 36) to another segment adjacent thereto and preventing interference between the

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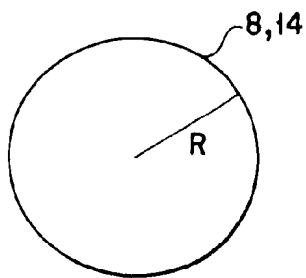


FIG. 2B

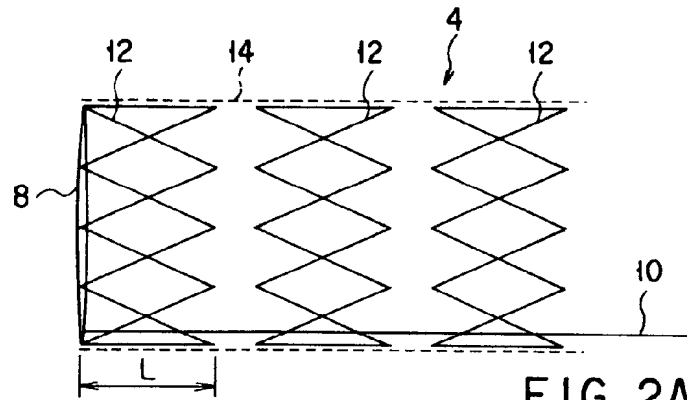


FIG. 2A

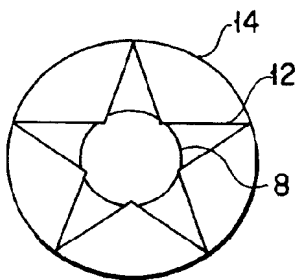


FIG. 2D

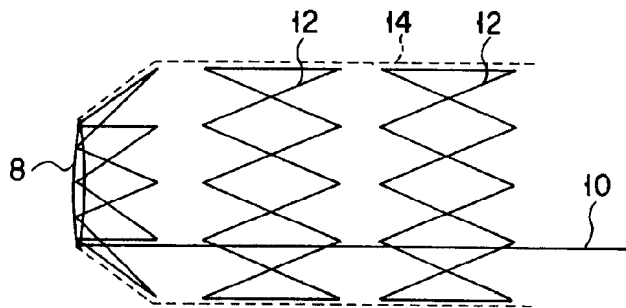


FIG. 2C

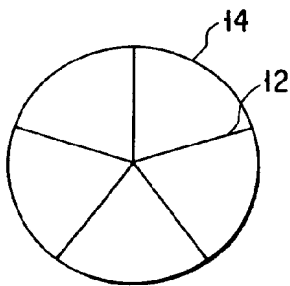


FIG. 2F

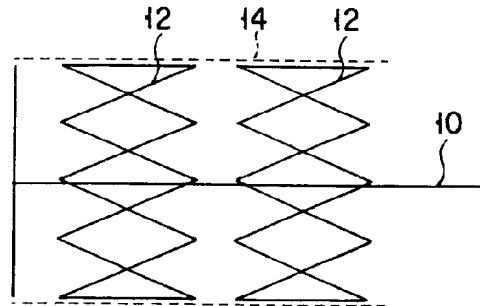


FIG. 2E

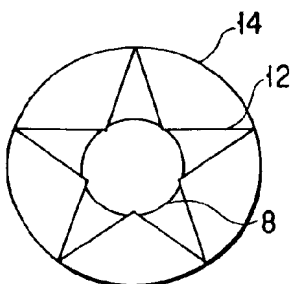


FIG. 2H

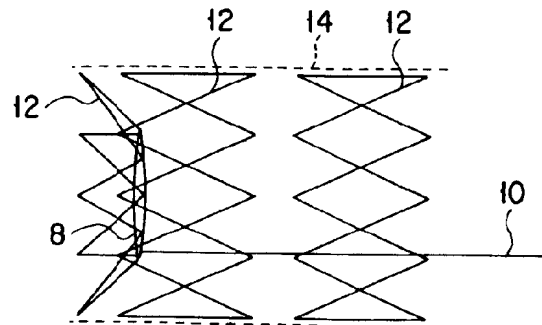


FIG. 2G

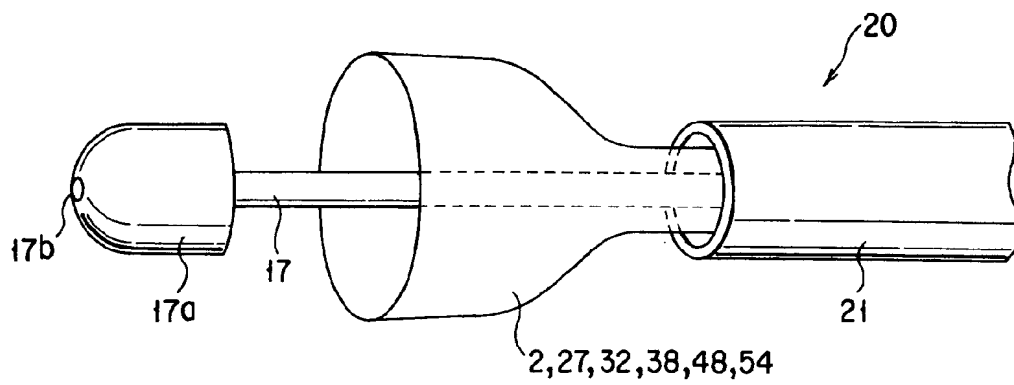


FIG. 3A

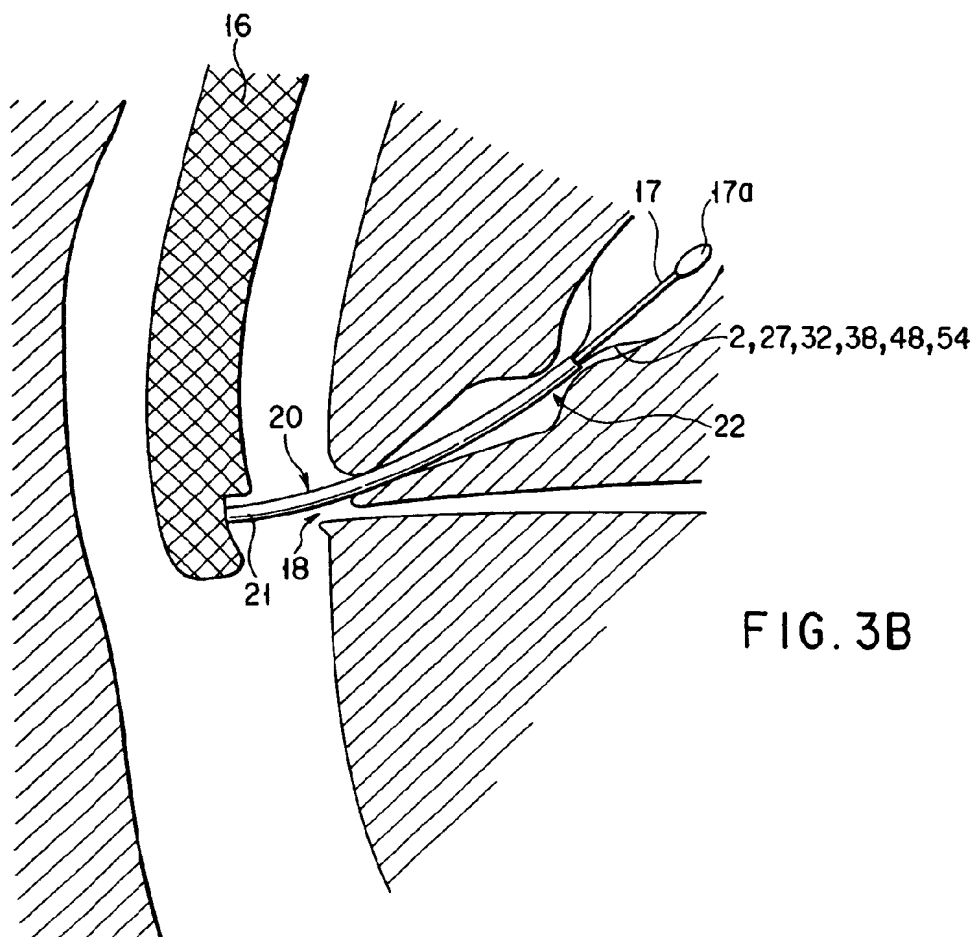


FIG. 3B

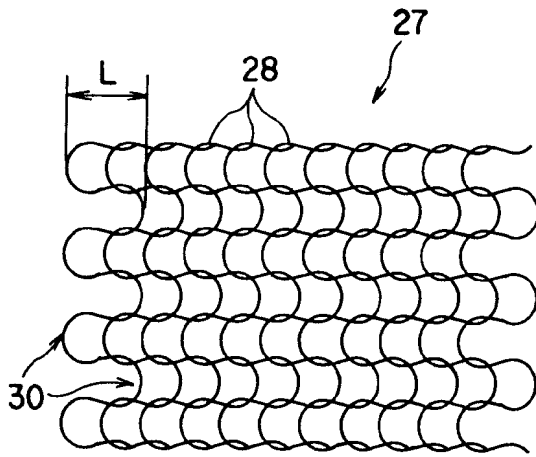


FIG. 4A

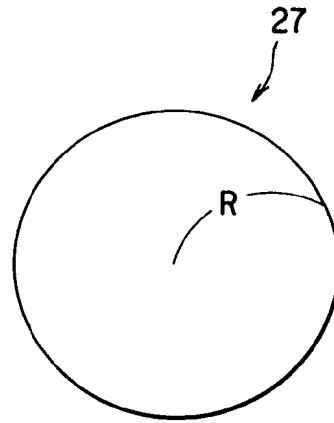


FIG. 4B

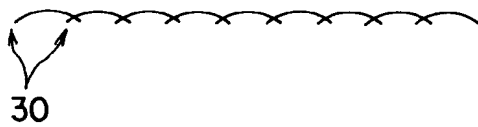
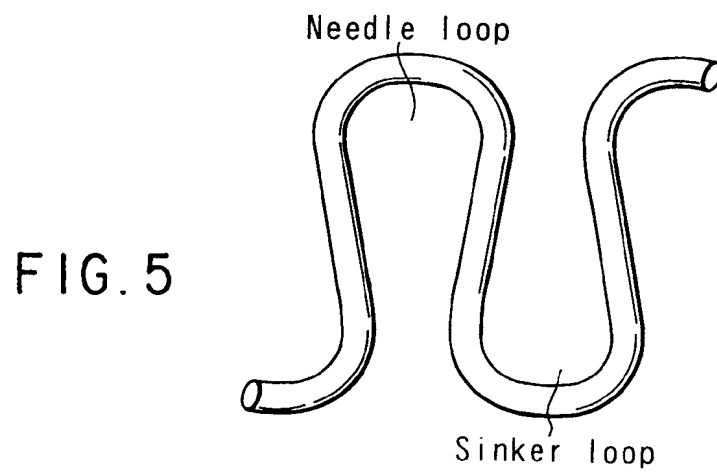


FIG. 4C



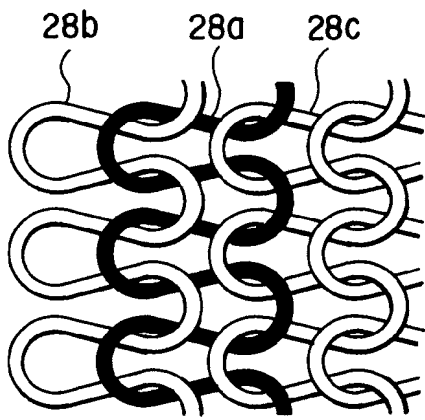


FIG. 6A

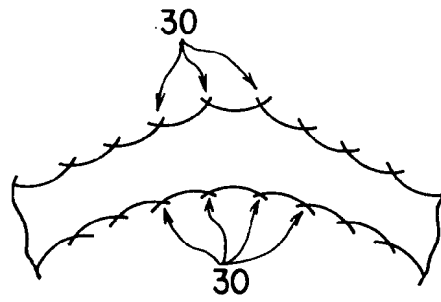


FIG. 6B

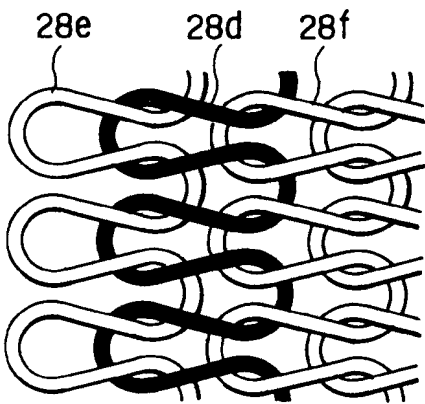


FIG. 7A

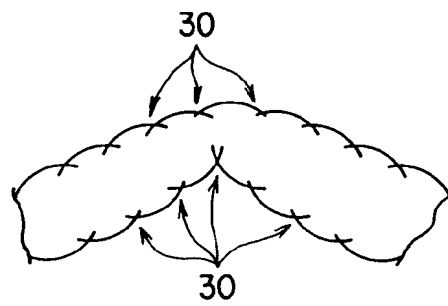


FIG. 7B

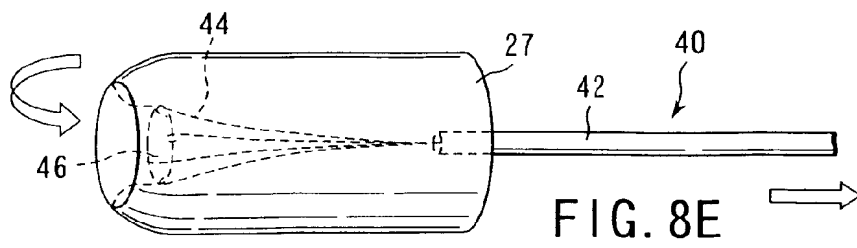
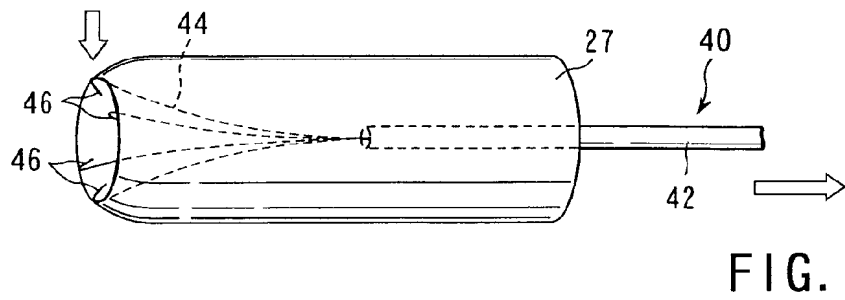
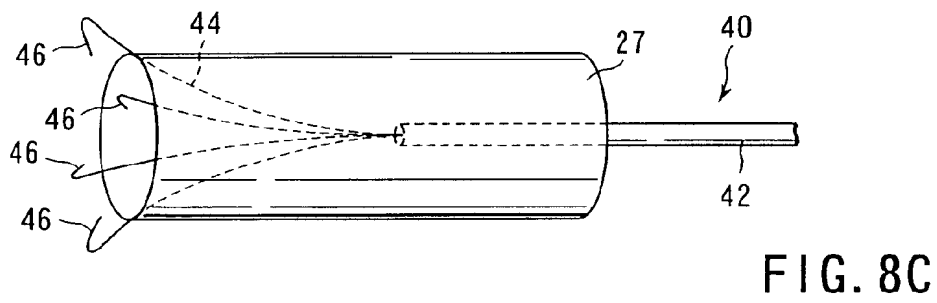
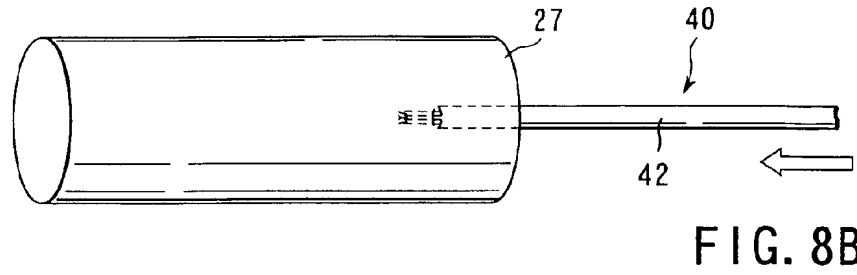
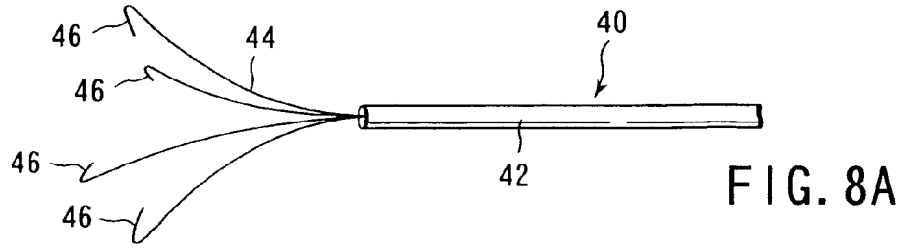


FIG. 9A

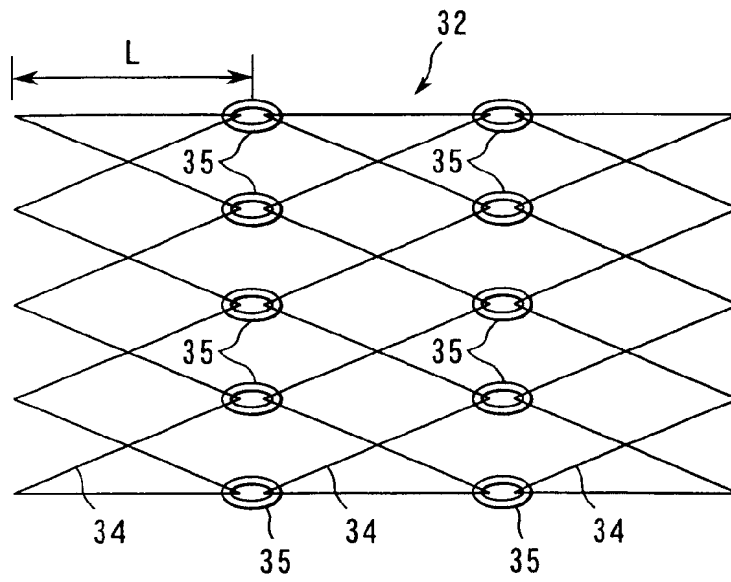


FIG. 9B

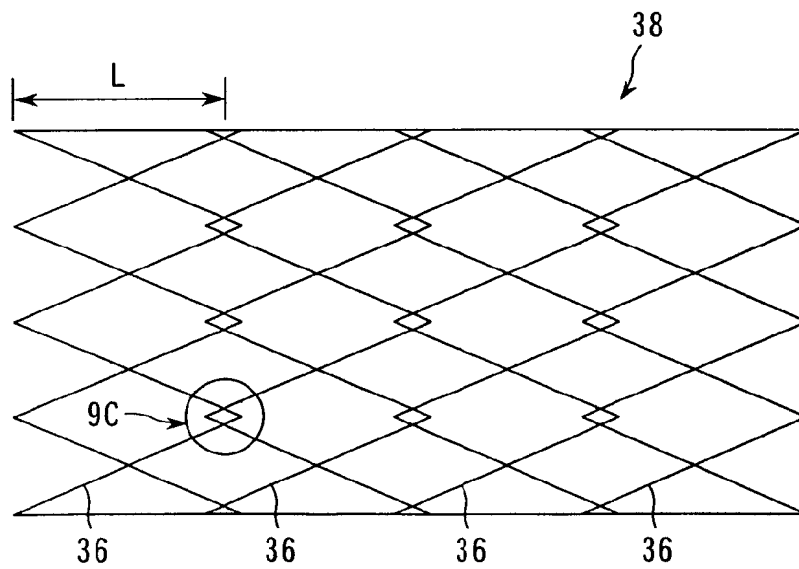
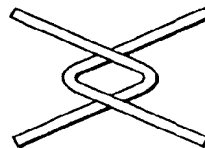


FIG. 9C



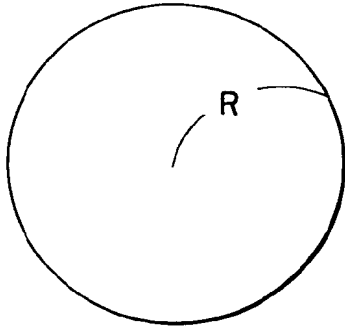


FIG. 10B

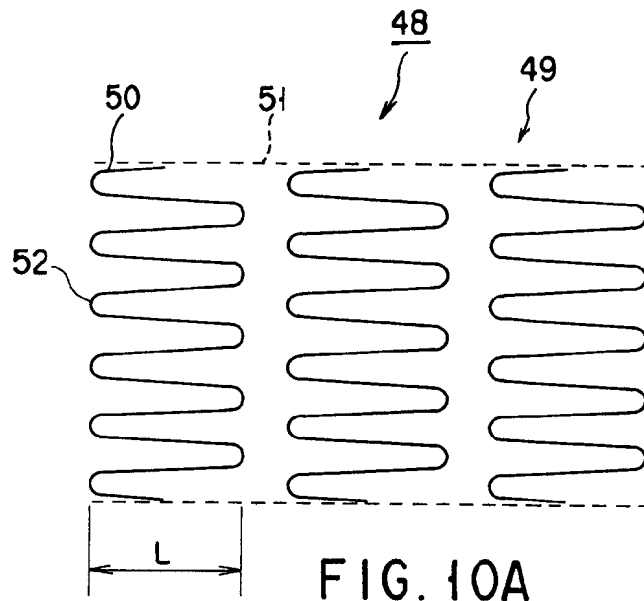


FIG. 10A

